KBC-28343
Revision 3

Disposal of K Basin Ion Exchange Column Evaluation

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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Document Type: RPT Program/Project: KBC

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Date Published
March 2008

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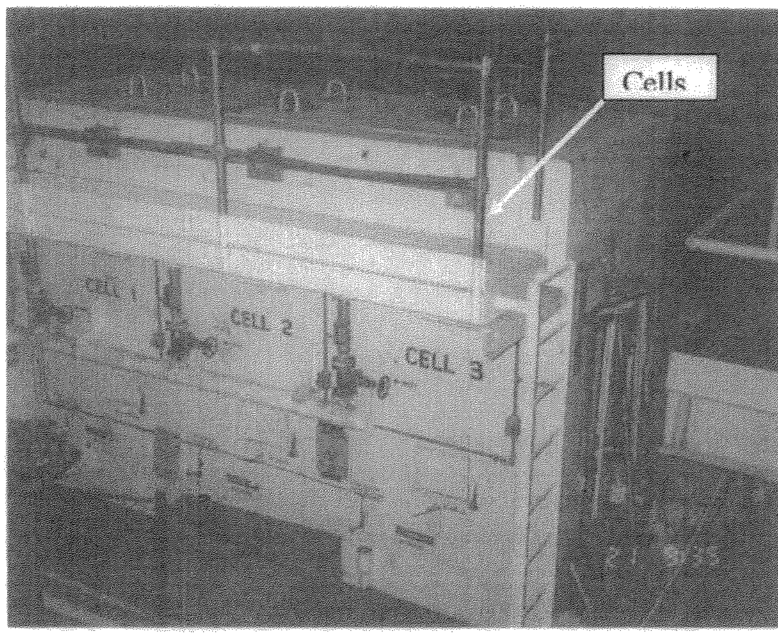
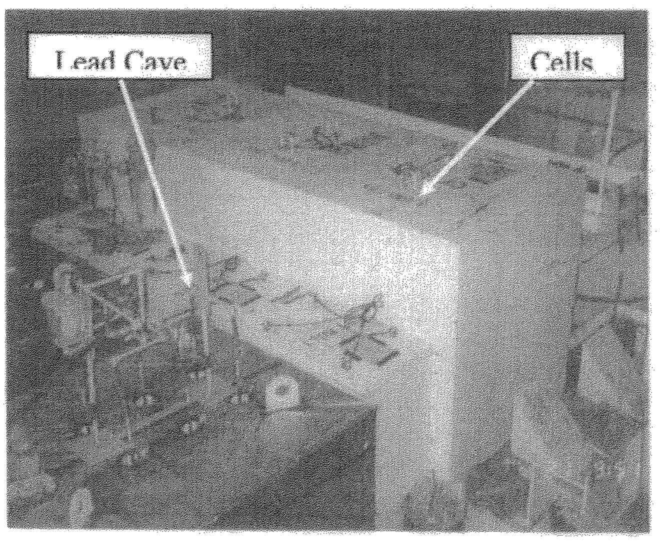
J.E. Bratton 3/19/2008
Release Approval Date

Printed in the United States of America

Summary



Currently, the K Basins Closure (KBC) Project has six spent Ion Exchange Columns (IXC) located in the 105-K East (KE) Basin that exhibit extremely high dose rates. The IXCs were used prior to the deployment of Ion Exchange Modules (IXM) to treat basin water. During operation, one IXC was placed into each concrete cell (3) and connected to the recirculation loop. Once the IXCs were spent, they were removed from the cells and placed into one of six positions within the lead enclosed storage cave. The last set of three IXCs to be used to process basin water remain in the concrete cells they resided in during the time they were processing the basin water. There are also three IXCs, spent and removed from the cells stored in lead caves directly adjacent to the concrete cells. As part of the D&D of this facility these IXCs must be dispositioned. In the past, the IXCs were loaded into the "Big Bertha" cask and shipped to the burial grounds for disposal. However due to ALARA and transportation issues the KBC Project believes the appropriate methodology for disposition of this waste is to build a metal form around the IXCs, remove the access ports from the storage areas and fill all with grout to stabilize the waste and reduce the dose consequence, and dispose of the waste as a monolith at the Environmental Restoration Disposal Facility (ERDF).



This white paper demonstrates the need for waste stabilization, and that the stabilized waste is acceptable for disposal at ERDF, even though there will be voids within the waste matrix that exceed the requirements found in the ERDF waste acceptance criteria.

1.0 BACKGROUND

Approximately 2,100 metric tons of uranium as Spent Nuclear Fuel (SNF) were stored within two water filled pools, the 105-KE Basin (KE Basin) and the 105-KW Basin (KW Basin). The ion exchange columns (IXCs) were generated from the treatment of the water in the KE Basin. Leakage from spent fuel stored in the KE Basin is the source of radionuclides dissolved in the basin water. These radionuclides are removed from the water at varying efficiencies by the IXCs.

The water recirculation equipment (termed the "main recirculation loop," or sometimes, the "primary recirculation loop") processed approximately 9 L/sec (150 gpm) of water through each of the basin's three bays via suction and discharge headers located about 2 m below the pool's surface. By 1981, the KE Basin was reactivated and three IXCs were added to the loop. Each IXC contains 142 L (5 ft^3) of strong acid cation/strong base anion, organic ion exchange resin, and Duolite® or Purolite® (mixed bed resin). (Duolite is a trademark of Rohm and Haas Company, Philadelphia, Penn.; Purolite is a registered trademark of Purolite International Limited, Llantrisant, Wales U.K.) The three IXCs were operated in parallel in order to provide the necessary water processing flow rate.

IXCs were used from 1981 through 1993 to maintain the water quality in the basins. The columns were drained after use in February 1993. IXCs are no longer in service at the KE Basin due to the high radiation exposure during handling. There are no plans to generate additional IXCs.

2.0 WASTE CONFIGURATION AND CHARACTERISTICS

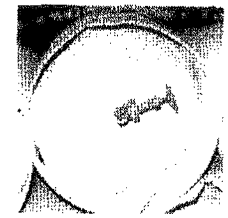
This section describes the physical, radiological, and chemical characteristics of the final monolith waste form. As stated previously, the KE Basin must disposition the last six IXCs currently stored at the 105 KE Basins. These six IXCs are stored in close proximity to each other in a combination of lead caves and small concrete cells.

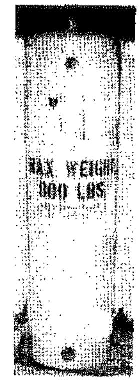
The KBC project is proposing to build a metal form around the storage location, unhook the three IXCs in the cells from all hoses (when the system was taken out-of-service the IXCs were drained but were not unhooked from the system), remove all cell and lead cave access ports, and fill the entire area with flowable grout to stabilize the waste form, and reduce transportation risks and radiological concerns associated with the management of these high-dose-rate items. Once the monolith has cured, the KBC would cut the floor of the storage area on the outside of the form and include the material in the K Basin monolith waste stream for disposal at ERDF.

Since there is no way to ensure grout flows into the IXC column itself, the KBC project assumes that the IXC monolith will exhibit void spaces that do not meet the greater than 2" or less than 10 percent void criteria currently found in the ERDF Acceptance Criteria. However, since the waste will be fully encapsulated with grout, the waste form meets waste encapsulation requirements that would prevent possible future subsidence or migration of any contaminants including lead from the lead shielding.

2.1 Physical Characteristics

The lead caves and concrete cells currently containing the IXCs will be solidified/stabilized in the grouted waste form before disposal at the ERDF. The waste materials contained in the grouted IXC monolith will have the following characteristics;





- Each IXC is an 18-inch diameter schedule 10 pipe with 1/4" walls and a 17.5" inner diameter.
- The columns are 59 inches long with a mixed bed resin occupying the middle 41 inches when swelled with water.
- The columns have a designed pressure capacity of 75 psi and have been tested at 125 psi.
- They contain a 1/2" bronze gate valve at the bottom and a 2" diameter distribution pipe at the top of the column.
- About 220 pounds of dewatered resin is supported within the carbon steel column by a stainless steel screen that is welded to the side walls of the columns.
- A 3/4" NucFil® filter with a 1/8" opening to the filter has been placed in the 3/4" inlet to the three IXCs stored in lead caves. (NucFil is a registered trademark of Nuclear Filter Technology, Incorporated of Golden, Colo.)
- All columns were drained when they were removed from service and even if a small amount of liquid remained entrained in the column, it would have been removed by the normal evaporative process during the twelve plus years the IXCs have been stored at the basin. The resins are expected to be dewatered to the extent that would allow them to pass a paint filter test.
- The resin occupies the center of the column. See Drawing H-1-34833.
- Table 2.2-1 calculates the IXCs, cells, caves, piping and flooring void volume and material volume and weight prior to grouting the monolith. This table was added to show total void volume of the original configuration to better represent the voids that may exist after grouting.Table 2.2-2 presents estimates of the constituents, volumes, and weights associated with the monolith form based on 150 lb/ft^3 density structural concrete and 105 lb/ft^3 density grout being added. The monolith is designed to have maximum measurements of approximately 9 ft 1 in. wide, 15 ft 1 in. long, and 12 ft 8 in. high and exhibit a total weight of 225,278.8 lb.

The total possible ungrouted void space (assumes no grout infiltration into the IXCs) of the monolith containing the six IXCs is conservatively estimated to total 21.3 ft^3 (i.e., approximately 160 gal).

2.2 Radiological Characteristics of the IXC Monolith

The internal and external surfaces of the IXCs, associated piping, and internal surfaces of the caves and cells are contaminated. In addition, the resin beads contained within each IXC have captured substantial quantities of radionuclides. Table 2.2-3 provides a listing of the measured and calculated dose rates for the six IXCs.

Table 2.2-1. Cell and Cave Gross Void Volume and Weight Before Grouting.

COMPONENT	VOID VOLUME (ft^3)	MATERIAL VOLUME (ft^3)	COMPONENT WEIGHT (lbs)
CONCRETE CELLS (per drawing H-1-45071, H-1-34789, H-1-34790, H-1-34793, H-1-34794) 6' W x 15' L x 10'-1" H			
3-IXCs	10.2	2.0	960.0
Resin	0.0	15.0	660.0
Associated Piping and misc. steel (Estimated)	0.9	1.2	600.0
Concrete Cell (Calculated by subtracting the cell and void volumes from the total cell dimensions)	0.0	699.0	104,850.0
Cavity Void Volume	175.1	0.0	0.0
Cell Penetration void volume	2.7	0.0	0.0
Drain void volume	3.3	0.0	0.0
Subtotal	**192.2**	**717.2**	**107,070.0**
LEAD CAVES (per drawing H-1-45071, H-1-34789) 165"L x 30"W x 72"H			
3-IXCs	10.2	2.0	960.0
Resin	0.0	15.0	660.0
Associated Piping (Estimated)	0.0	0.0	0.0
Steel Skin - Front (.5" x 164" x 72")	0.0	3.4	1,674.2
Steel Skin - Sides (0.5" x 27.5" x 72") x 2	0.0	1.1	561.5
Steel Skin - Top (0.5" x 30" x 165")	0.0	1.4	701.8
Lead Shielding - Front (2" x 164" x 72")	0.0	13.7	9,703.3
Lead Shielding - Sides (2" x 27.5" x 72") x 2	0.0	4.6	3,254.2
Lead Shielding - Top (2" x 30" x 165")	0.0	5.7	4,067.7
Steel Frame, calculated	0.0	2.7	1,342.0
Void Space in Cave (calculated by subtracting the total volume occupied by the IXCs and total internal volume of the cave)	153.2	0.0	0.0
Subtotal	**163.4**	**49.7**	**22,924.7**
Existing Slabs 8'-10"W x 15'-1"L x 12'-8-1/2"H, plus cutting allowance at slabs			
Concrete Floor Under Lead Cave (2.96' W x 14.5'L x 1.33'D) (1' slab per drawings H-1- 21072, H-1-21073 and 4" topping per walk downs)	0.0	57.2	8,581.9
Washing Pit topping added when IXC Cell Enclosure formed, per H-1-34793 (cut to 15'-2"x6'-2", 11" height)	0.0	85.7	12,861.0
Washing Pit Concrete slab, 1'-8" thick, H-1-21072	0.0	155.9	23,388.4
Subtotal	**0.0**	**298.9**	**44,831.3**
Total monolith	**355.6**	**1,065.7**	**174,826.0**

H-1-21072, 1983, *Structural Concrete Sections & Details at Elev.0 Feet-0 Inches Storage & Transfer Area,* United Nuclear Industries, Inc., Richland, Washington.
H-1-21073, 1955, *Structural Concrete Sections & Details at Elev.0'0" Storage & Transfer Area,* General Electric, Richland, Washington.
H-1-34789, 1987, *Ion Exchange Column,* United Nuclear Industries, Inc., Richland, Washington.
H-1-34790, 1986, *Parallel Ion Exchange System Piping Plan & Section*, Energy Research & Development Administration, Richland Washington.
H-1-34793, 1979, *Structural Plans and Sections*, U.S. Energy Research & Development Administration, Richland Washington.
H-1-34794, 1984, *Structural Sections and Miscellaneous Details,* U.S. Energy Research & Development Administration, Richland Washington.
H-1-45071, 2000, *K-East Ion Exchange Module General Arrangement & PID,* Westinghouse Hanford Company, Richland, Washington.

IXC = Ion Exchange Column.

Table 2.2-2. Total Monolith Volume and Weight After Grouting.

COMPONENT	VOID VOLUME[1] (ft^3)	MATERIAL VOLUME[2] (ft^3)	COMPONENT WEIGHT[3] (lbs)
CONCRETE CELLS (per drawing H-1-45071, H-1-34789, H-1-34790, H-1-34793, H-1-34794) 6' W x 15' L x 10'-1" H			
3-IXCs	10.2	2.0	960.0
Resin	0.0	15.0	660.0
Associated Piping and misc. steel (Estimated)	0.9	1.2	600.0
Concrete Cell (Calculated by subtracting the cell and void volumes from the total cell dimensions)	0.0	699.0	104,850.0
Grout in Cell (Calculated by subtracting the volume of the IXCs and piping from the open cell space)	0.0	181.1	19,016.6
Subtotal	**11.1**	**898.3**	**126,086.6**
LEAD CAVES (per drawing H-1-45071, H-1-34789) 165"L x 30"W x 72"H			
3-IXCs	10.2	2.0	960.0
Resin	0.0	15.0	660.0
Associated Piping (Estimated)	0.0	0.0	0.0
Steel Skin - Front (.5" x 164" x 72")	0.0	3.4	1,674.2
Steel Skin - Sides (0.5" x 27.5" x 72") x 2	0.0	1.1	561.5
Steel Skin - Top (0.5" x 30" x 165")	0.0	1.4	701.8
Lead Shielding - Front (2" x 164" x 72")	0.0	13.7	9,703.3
Lead Shielding - Sides (2" x 27.5" x 72") x 2	0.0	4.6	3,254.2
Lead Shielding - Top (2" x 30" x 165")	0.0	5.7	4,067.7
Steel Frame, calculated	0.0	2.7	1,342.0
Grout in Cave (calculated by subtracting the total volume occupied by the IXCs and total internal volume of the cave)	0.0	153.2	16,086.4
Subtotal	**10.2**	**202.9**	**39,011.0**
Existing Slabs and MONOLITH FORM (3" grout plus 1/2" steel plate outside exposed top and sides of Lead Cave and 1/2" steel plate, top & sides of IXC enclosure) 8'-10"W x 15'-1"L x 12'-8-1/2"H, plus cutting allowance at slabs			
Concrete Floor Under Lead Cave (2.96' W x 14.5'L x 1.33'D) (1' slab per drawings H-1- 21072, H-1-21073 and 4" topping per walk downs)	0.0	57.2	8,581.9
Washing Pit topping added when IXC Cell Enclosure formed, per H-1-34793 (cut to 15'-2"x6'-2", 11" height)	0.0	85.7	12,861.0
Washing Pit Concrete slab, 1'-8" thick, H-1-21072	0.0	155.9	23,388.4
Steel Skin at Lead Cave top, front and sides (1/2" steel plate, at outer dimensions of grout 2'-9"W x 14'-3"L x 6'-5-1/2"H)	0.0	6.9	3,404.9
Steel Skin (1/2" steel plate) at IXC Cell Enclosure top, front, sides and back (except against lead cave)	0.0	15.9	7,780.0
Grout on the Exterior at Lead Cave (3" on top, front and sides, use dimensions to grout centerlines to calculate volume: ht 76", length 168", width 31.5")	0.0	39.7	4,165.0
Subtotal	**0.0**	**361.4**	**60,181.2**
Total monolith	**21.3**	**1,462.5**	**225,278.8**

H-1-21072, 1983, *Structural Concrete Sections & Details at Elev.0 Feet-0 Inches Storage & Transfer Area*, United Nuclear Industries, Inc., Richland, Washington.
H-1-21073, 1955, *Structural Concrete Sections & Details at Elev.0'0" Storage & Transfer Area*, General Electric, Richland, Washington.
H-1-34789, 1987, *Ion Exchange Column*, United Nuclear Industries, Inc., Richland, Washington.
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H-1-34793, 1979, *Structural Plans and Sections*, U.S. Energy Research & Development Administration, Richland Washington.
H-1-34794, 1984, *Structural Sections and Miscellaneous Details*, U.S. Energy Research & Development Administration, Richland Washington.
H-1-45071, 2000, *K-East Ion Exchange Module General Arrangement & PID*, Westinghouse Hanford Company, Richland, Washington.

[1] Void volume is an estimate and will be re-calculated once grout is added to the monolith.
[2] Material volume is an estimate and will be re-calculated once grout is added to the monolith.

Table 2.2-2. Total Monolith Volume and Weight After Grouting.

COMPONENT	VOID VOLUME[1] (ft^3)	MATERIAL VOLUME[2] (ft^3)	COMPONENT WEIGHT[3] (lbs)

[3] Component weight is an estimate and will be re-calculated once grout is added to the monolith.

IXC = Ion Exchange Column.

Table 2.2-3. IXC Dose Rates[1]

IXC	Dose Rate (R/hr)
IXCs – Cells (measured)	
IXC-1	42.9
IXC-2	53.9
IXC-3	19.5
IXCs – Lead Cave (Calculated)	
IXC-1	21.5
IXC-2	27
IXC-3	10

The radiological characterization of the monolith is assumed to be solely from the IXCs. The radionuclide inventories for the IXCs are calculated for Cs-137, Sr-90 Pu-238, and Pu-239 by subtracting the outlet concentration from the inlet concentration to determine the concentration captured on the IXC, then multiplying times the flow rate, and time in service. The activities of other isotopes were calculated based on the method presented in section 2.3 of HNF-6495, Revision 1 for characterization of IXM units. Table 2.2-4 provides a listing of the quantity of each radionuclide in the monolith based on this methodology.

[1] Dose rates presented in Table 2.2-3 are a combination of calculated and measured values. The dose rates for the IXCs currently stored in the cells are measured values. However, no actual surface dose rates are available for the IXCs currently stored in the lead caves. Therefore, the KBC project calculated the dose rate of IXCs located in the lead cave based upon IXC run-time and the dose rate measured on IXCs located in the cells. This is believed to be very conservative, produce a low estimate, due to the fact that the IXCs are more efficient earlier in their life and thus captures more radionuclides. A low estimate of dose rate is conservative as it is only being used to estimate personnel exposure for the purpose of determining the waste management pathway. The dose rates are not being used to estimate the radionuclide inventory.

Table 2.2-4. Monolith Radionuclide concentrations

	Nuclide Distribution (unitless)	Analysis Radionuclide Inventory (Ci)	Total Radionuclide Inventory (Ci)	
H-3	1.26E+00		1.26E+02	1
Co-60	4.94E-04		4.95E-02	1
Ni-63	3.81E-04		3.82E-02	1
Sr-90	4.30E-01	4.32E+01	4.32E+01	
Sb-125	5.03E-04		5.05E-02	1
Cs-137	1.00E+00	1.00E+02	1.00E+02	
Pm-147	6.33E-03		6.36E-01	1
Sm-151	1.49E-02		1.49E+00	1
Eu-152	5.86E-05		5.88E-03	1
Eu-154	5.39E-03		5.41E-01	1
Eu-155	7.15E-04		7.18E-02	1
U-234	4.87E-04		4.89E-02	2
U-235	9.75E-05		9.79E-03	2
U-238	1.95E-04		1.96E-02	2
Pu-238	2.86E-03	2.88E-01	2.88E-01	
Pu-239	2.26E-02	2.27E+00	2.27E-02	
Pu-240	1.23E-02		1.24E+00	2
Pu-241	4.92E-01		4.94E+01	2
Am-241	3.65E-02		3.66E+00	2
Cm-244	1.14E-04		1.14E-02	2
All values are decay corrected to 7/1/05.				
Notes:				
1. Determined by ratio to Cs-137.				
2. Determined by ratio to Pu-239.				

Placing grout in the interior of the IXC cells and lead cave is necessary to comply with the following requirements:

- Fix in place the source and existing material that provides shielding so that the dose rate exterior to the waste form remains low,
- Fix internal contamination for burial and transportation (300,000 dpm beta/gamma per 100 cm^2 smearable), and
- Minimize void space to the extent practicable.

Grout and forms around the exterior of the IXC cells and lead cave will be placed as necessary to provide a waste form with structural integrity necessary for transport, macroencapsulation treatment of lead, and compliance with the ERDF WAC.

The Branch Technical Position (BTP) *Issuance of final Branch Technical Position on Concentration Averaging and Encapsulation, Revision in Part to Waste Classification Technical Position* (NRC 1995) describes situations where both encapsulants such as grout and waste masses together may be used in waste class determinations. The encapsulation monolith containing six IXCs is similar to the BTP situation described in Section 3.7 (Encapsulation of Solid Material). The concentration of radionuclides may be averaged over the waste and encapsulant if:

1. The volume and attributes of the encapsulated waste comply with the constraints established in Appendix C of the BTP,
2. the solidified mass meets the waste form structural criteria of 10 CFR 61.56 for class B and C waste, and
3. the disposal unit containing the encapsulated mass is segregated from disposal units containing class A wastes, that do not meet the structural stability requirements of 10 CFR 61.56(b). (Not required for ERDF disposal)

Encapsulating and packaging for transporting and disposing of the K East basin IXC monolith will comply with the applicable requirements stated above. The requirements of Appendix C of the BTP are listed along with compliance methods on Table 2.2-5. A grout will comply with the waste form structural integrity requirements as specified in 10 CFR 61.56 as it does not degrade in the disposal environment and can be formulated to provide adequate strength for disposal conditions. The ERDF WAC does not specifically require adherence to the structural stability requirements of 10 CFR 61.56(b); therefore, segregation of encapsulated IXCs is not required.

Table 2.2-5. Branch Technical Position Appendix C Requirements and Requirement Compliance

Requirements	Method of Compliance
A minimum solidified volume or mass for encapsulation should be that which can reasonably be expected to increase the difficulty of an inadvertent intruder moving the waste by hand without the assistance of mechanical equipment.	The volume of the encapsulated six IXCs is about 2800 cubic feet (CF) which is too large for movement by hand.

Table 2.2-5. Branch Technical Position Appendix C Requirements and Requirement Compliance

Requirements	Method of Compliance
A maximum solidified volume or mass for encapsulation of a single discrete source (from which concentrations are determined) should be .2 m^3 or 500 Kg (typical 55-gallon drum). Larger volumes and masses may be used for encapsulation of single sources but, in general, unless a specific rationale is provided, no credit beyond the volume or mass indicated should be considered when determining waste concentrations. Encapsulation of multiple sources (e.g. filters) in larger volumes may be considered acceptable under the Alternative provisions paragraph.	The IXC, cells, and lead cave are 1113 CF which is larger than a 55-gallon drum (7.4 CF). However, the waste contains multiple sources including six IXCs and exhibits substantial surface contamination (300,000 dpm beta/gamma per 100 cm^2 smearable) on the interior of the cells and lead cave. The Alternate Provisions paragraph requires compliance with performance objectives in Subpart C of 10 CFR Part 61, compliance is assured via compliance with the ERDF WAC. The ERDF WAC in part presents requirements necessary to ensure compliance based on a performance assessment written to the objectives of Subpart C of 10 CFR Part 61.
A maximum amount of gamma-emitting radioactivity (e.g., Cs-137/Ba-137m, Nb-94) or radioactive material generally acceptable for encapsulation is that which, if credit is taken for a 500-year decay period, would result in a dose rate of less than 0.2 uSv/hr (.02 mrem/hr) on the surface of the encapsulating media. The calculation to determine compliance with this criteria may consider the minimum attenuation factor provided by the encapsulating media, in general, this factor should not exceed an attenuation factor that would be provided by 15 inches of concrete encapsulating material. Furthermore, the maximum Cs-137/Ba-137m gamma-emitting generally acceptable for encapsulation in a single disposal container is 1.1 TBq (30 Ci).	Design the monolith to ensure compliance with transportation and disposal requirements including 500-year decay period to result in a dose rate of less than 0.2 uSv/hr (0.02 mrem/hr) on the surface of the encapsulating media. The maximum container loading of 30 curies of Cs-137/Ba-137 is based on the waste being in a 55-gallon drum. In this case, the waste is not in a container but rather is a large monolith. If the monolith were placed in the number of 55-gallon drums that are equivalent in volume to the monolith (i.e., the monolith volume that is appropriate for determining the waste class) it would fill 180 55-gallon drums. Therefore the equivalent Cs-137/Ba-137 inventory limit for the monolith is 236 times the 30 curie limit or 5,400 curies of Cs-137/Ba-137. The calculated monolith Cs-137/Ba-137 inventory is 100 curies which is much less than the equivalent limit of 5,400 curies Cs-137/Ba-137.

Table 2.2-5. Branch Technical Position Appendix C Requirements and Requirement Compliance

Requirements	Method of Compliance
A maximum amount of any radionuclide that should be encapsulated in a single disposal container intended for disposal at a commercial low-level waste disposal facility is that which, when averaged over the waste and the encapsulating media, does not exceed the maximum concentration limits for Class C waste, as defined in Tables 1 and 2 of 10 CFR 61.55.	The radionuclide inventory has been established. The monolith design will be controlled and compliance determined prior to preparing the monolith by calculating radionuclide concentrations for comparison with 10 CFR 61.55 thresholds
In all cases when a discrete source of radioactive solid waste is encapsulated, written procedures should be established to ensure that the radiation source(s) is reasonably centered within the encapsulating medium.	IXCs located in cells and lead cave ensures placement of IXCs inside the encapsulant. Procedures will be employed governing the encapsulation process the ensure IXCs are centered in the monolith to the extent practicable.

Based on evaluation of the BTP, the appropriate mass and volume of the waste form over which to average the waste radioactivity is the total monolith less the unused portion of the lead cave (half of the cave does not contain IXCs) and the structure exterior to the cells and lead cave required for structural purposes only. The lead cave is half empty so half of the grout filling the cave is deducted from the weight of Table 2.2-1 to determine the waste weight. Also, the metal steel skin and ribbing and outer one foot layer of grout is also deducted from Table 2.2-1 to determine the waste weight because they serve structural purposes only. The calculated waste weights used for classification calculations are shown in Table 2.2-6. This equates to a waste classification waste weight of 206,415.8 lbs when the weight deductions described above are subtracted from the total monolith volume and weight presented in Table 2.2.-2.

Table 2.2-6. Monolith Volume and Weight Suitable for Waste Classification.

COMPONENT	VOID VOLUME[1] (ft³)	MATERIAL VOLUME[2] (ft³)	COMPONENT WEIGHT[3] (lbs)
CONCRETE CELLS (per drawing H-1-45071, H-1-34789, H-1-34790, H-1-34793, H-1-34794) 6' W x 15' L x 10'-1" H			
3-IXCs	10.2	2.0	960.0
Resin	0.0	15.0	660.0
Associated Piping and misc. steel (Estimated)	0.9	1.2	600.0
Concrete Cell (Calculated by subtracting the cell and void volumes from the total cell dimensions)	0.0	699.0	104,850.0
Grout in Cell (Calculated by subtracting the volume of the IXCs and piping from the open cell space)	0.0	181.1	19,016.6
Subtotal	**11.1**	**898.3**	**126,086.6**
LEAD CAVES (per drawing H-1-45071, H-1-34789) 165"L x 30"W x 72"H			
3-IXCs	10.2	2.0	960.0
Resin	0.0	15.0	660.0

Table 2.2-6. Monolith Volume and Weight Suitable for Waste Classification.

COMPONENT	VOID VOLUME[1] (ft³)	MATERIAL VOLUME[2] (ft³)	COMPONENT WEIGHT[3] (lbs)
Associated Piping (Estimated)	0.0	0.0	0.0
Steel Skin - Front (.5" x 164" x 72")	0.0	3.4	1,674.2
Steel Skin - Sides (0.5" x 27.5" x 72") x 2	0.0	1.1	561.5
Steel Skin - Top (0.5" x 30" x 165")	0.0	1.4	701.8
Lead Shielding - Front (2" x 164" x 72")	0.0	13.7	9,703.3
Lead Shielding - Sides (2" x 27.5" x 72") x 2	0.0	4.6	3,254.2
Lead Shielding - Top (2" x 30" x 165")	0.0	5.7	4,067.7
Steel Frame, calculated	0.0	2.7	1,342.0
Grout in Cave (calculated by subtracting the total volume occupied by the IXCs and half the internal volume of the cave)	0.0	62.9	6,605.2
3" internal grout layer for lead encapsulation in other half of lead cave (Use centerline of grout, reduce dimensions by 1.5")	0.0	17.2	1,803.0
Subtotal	**10.2**	**129.7**	**31,332.9**
CONCRETE FLOOR (per drawing H-1- 21072, H-1-21073, H-1-34793)			
Concrete Floor Under Lead Cave (2.96' W x 14.5'L x 1.33'D) (1' slab per drawings H-1- 21072, H-1-21073 and 4" topping per walk downs)	0.0	57.2	8,581.9
Washing Pit topping added when IXC Cell Enclosure formed, per H-1-34793 (cut to 15'-2"x6'-2", 11" height)	0.0	85.7	12,861.0
Washing Pit Concrete slab, 1'-8" thick, H-1-21072	0.0	155.9	23,388.4
Grout on the Exterior at Lead Cave (3" on top, front and sides, use dimensions to grout centerlines to calculate volume: ht 76", length 168", width 31.5")	0.0	39.7	4,165.0
Subtotal	**0.0**	**338.5**	**48,996.3**
Total Waste	**21.3**	**1,366.5**	**206,415.8**

H-1-21072, 1983, *Structural Concrete Sections & Details at Elev.0 Feet-0 Inches Storage & Transfer Area,* United Nuclear Industries, Inc., Richland, Washington.
H-1-21073, 1955, *Structural Concrete Sections & Details at Elev.0'0" Storage & Transfer Area,* General Electric, Richland, Washington.
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H-1-34794, 1984, *Structural Sections and Miscellaneous Details,* U.S. Energy Research & Development Administration, Richland Washington.
H-1-45071, 2000, *K-East Ion Exchange Module General Arrangement & PID,* Westinghouse Hanford Company, Richland, Washington.
[1] Void volume is an estimate and will be re-calculated once grout is added to the monolith.
[2] Material volume is an estimate and will be re-calculated once grout is added to the monolith.
[3] Component weight is an estimate and will be re-calculated once grout is added to the monolith.

Using the monolith volume and weight applicable for radioactive waste classification as described above, the monolith was evaluated for ERDF acceptance and the results are provided on Table 2.2-7. The limiting condition for ERDF acceptance is if the waste is greater than NRC class C (GTCC) waste. The waste is not at the GTCC level, as the sum of factions at the bottom of the table are less than one, so the radionuclide content of the waste is acceptable for ERDF disposal. The DOE transuranic content was also calculated to be 79.6 nCi/g which is less than the transuranic threshold of 100 nCi/g.

Table 2.2-7 Radioactive Waste Class Calculation

Nuclide	Total Monolith Inventory (Ci)	Estimated Rad Inv. in Monolith (Ci/g)	Estimated Rad Inv. in Monolith (Ci/Cm^3)	NRC Table 1 (Ci/Cm^3)	NRC Table 1 (nCi/g)	NRC Table 1 Ratio (unitless)	NRC Table 2 Col. 3 (Ci/Cm^3)	NRC Table 2 Ratio (unitless)	DOE TRU (nCi/g)
C-14	6.20E-03	6.61E-11	1.62E-04	8		2.03E-05			
Ni-63	3.82E-02	4.08E-10	1.00E-03				700	1.43E-06	
Sr-90	4.32E+01	4.61E-07	1.13E+00				7000	1.61E-04	
Tc-99	2.58E-02	2.75E-10	6.74E-04	3		2.25E-04			
Cs-137	1.00E+02	1.07E-06	2.63E+00				4600	5.71E-04	
Np-237	6.05E-04	6.45E-12	1.58E-05		100	6.45E-05			6.45E-03
Pu-238	2.88E-01	3.07E-09	7.52E-03		100	3.07E-02			3.07E+00
Pu-239	2.27E+00	2.42E-08	5.93E-02		100	2.42E-01			2.42E+01
Pu-240	1.24E+00	1.32E-08	3.24E-02		100	1.32E-01			1.32E+01
Pu-241	4.94E+01	5.27E-07	1.29E+00		3500	1.51E-01			
Am-241	3.66E+00	3.91E-08	9.58E-02		100	3.91E-01			3.91E+01
Am-242m	1.97E-03	2.10E-11	5.15E-05		100	2.10E-04			2.10E-02
Pu-242	5.71E-04	6.09E-12	1.49E-05		100	6.09E-05			6.09E-03
Am-243	1.25E-03	1.33E-11	3.26E-05		100	1.33E-04			1.33E-02
Cm-242	1.63E-03	1.73E-11	4.25E-05		20000	8.67E-07			
Cm-244	1.14E-02	1.22E-10	2.99E-04		100	1.22E-03			
Sum of Fractions						9.48E-01		7.34E-04	
Sum of TRU									7.96E+01

2.3 Chemical Characteristics of the IXC Monolith

Direct sampling of the IXCs would be very difficult due to the extremely high dose rates and representativeness of the sample. So, process knowledge is the primary method of characterization supported by sampling for hazardous materials from the center of the KE Basin. The sampling protocol is based on SW-846. The IXCs are composed of metal (no regulated metals) and ion exchange resin (Purolite NRW-37 MSDS #29805), neither of which are hazardous.

Demineralized water containing various salts was pumped through the water treatment system, including the IXCs, from the basins. The sludge (due to corrosion of the damaged N Reactor fuel containers) in the bottom the KE Basin contains heavy metals but is not regulated as dangerous waste (Correspondence No. 0101943, 2001). However, only the water (and any salts dissolved in the water) was pumped to the IXCs. The last sampling of the water from the center of the KE Basin did not detect any regulated heavy metals. Only small quantities of copper, iron, calcium, and other non-regulated metals were detected. This corresponds with historical data showing the basin water to be non-hazardous. Periodic (at least yearly) sampling is performed to verify the continued status of the basin water as non-hazardous.

However the monolith, due to the lead cave, will contain regulated levels of lead.

3.0 DISCUSSION

Before disposal of the IXC monolith is deemed acceptable in the ERDF trench, all parties must concur with the following statements:

- The addition of grout is required and appropriate given the hazards associated with the package.
- The waste package has been configured in a manner to prevent subsidence even though void spaces may exist exceeding the ERDF void space requirements.
- The lead contained within the waste packaged meets the requirements of macroencapsulation.

Each of these areas are discussed in the following subsections. The KBC Project believes that a clear, concise, and technical discussion has been provided that demonstrates the above statements are true.

3.1 Justification for Grouting

A major component to the Hanford Site cleanup affecting the Columbia River corridor is eliminating the significant radiological source at the 100 K area. The removal of the 105KE Basin is a major part of this activity. The facility cannot be removed without the disposition of the six IXCs currently stored within the facility. In 2003, alternative approaches to accelerate the deactivation of the basins were evaluated and the Grout & Remove Alternative was selected. The Grout & Remove Alternative prepares and grouts debris in the basin under the *Record of Decision (ROD) for the K Basins Interim Remedial Action* (EPA, 1999a), for subsequent removal of the basin under the *Interim Action ROD for the 100 Area Remaining Sites, 100 Area Reactor Waste, and 200-CW-3 Waste* Sites (EPA, 1999b). Both RODs identify ERDF as the selected disposal location for debris and demolition waste that meets the ERDF WAC. If ERDF cannot be used, the alternatives Hanford could consider include the Central Waste Complex (CWC), Low Level Burial Grounds (LLBG), T Plant, and Waste Receiving and Processing facility.

In working through the disposition path associated with this waste stream, the project is required to develop a methodology for packaging, transporting, and disposing of the waste in a manner that is safe and provides the least risk to the public, environment, and workers associated with the Hanford site.

The safe transport to storage and disposal facilities is problematic for these IXCs. Three transportation packages were considered: 1) transport using a Type A box, 2) transport using a Type B cask, and 3) transport using an encapsulated waste form. The transportation of IXCs is compliant with U.S. Department of Transportation (DOT) regulations if the Type B cask is certified for that waste form and radionuclide inventory. The transportation of IXCs in Type A boxes or as an encapsulated waste form is not DOT-compliant but may be used for transport on the Hanford site if it can be demonstrated to provide equivalent safety to DOT. Transportation off the Hanford site requires use of a DOT-compliant package. A benefit of using a Type A box versus a Type B cask is that multiple boxes could be fabricated so that, unlike a cask, the boxes would not have to be unloaded and decontaminated for reuse.

Type A boxes are designed to meet the performance requirements of 49 CFR 173 specifications which are based on the safety of a package containing Type A quantities of radionuclides or less. The Type A package is not robust enough to meet the Type B requirements, so it would have to be modified and the package evaluated to demonstrate safety comparable to Type B requirements. Given that the IXC radionuclide inventory is dispersible (not encapsulated) and the radionuclide payload of the package is 50 times or more than the Type A limits, it is not credible to demonstrate safety equivalent to a Type B cask for a Type A package.

Type B casks are designed and certified to meet the performance requirements of 10 CFR 71 which is based on form and a radionuclide payload of Type B quantities. Several Type B casks were considered for transportation of IXCs. An evaluation of casks identified those that are considered credible candidates for transporting IXCs and are presented on Table 3.1-1. No cask is useable as is, and some could never be certified as DOT compliant. The cask that would be the quickest and easiest to certify for IXC transport is either the RH-72B or 10-160B. Design and procurement of special tools, cribbing, etc. and certification of either cask to a configuration and payload accommodating the IXCs would require about one to two years and $500,000 or more.

Transportation of IXCs as an encapsulated waste form package would not meet the requirements of 10 CFR 71 but it could be approved for Hanford site transportation based on the documentation of conditions where equivalent safety is provided. Transportation safety documentation has already been drafted for similar encapsulated waste forms of KE basin monoliths and an encapsulated sand filter. The IXC encapsulation would have to be designed and included in the existing draft safety documentation in order to obtain approval to transport the IXC waste form. Equivalent transportation safety to IXCs in an encapsulated form can be demonstrated because the form is not dispersible.

Table 3.1-1. Evaluation of Casks

Cask	Description/Issues for IXC Transport
RH-72B	The cask is certified for Type B remote handled TRU payloads but may not address the IXC waste form. It can handle up to 325 fissile gram equivalents (FGE) and would bound any of the IXCs. However, the size of the Inner Container (IC) would only allow for one IXC to be shipped at a time. Remote handling tools (shield enclosure) for closure of the IC would have to be developed. The payload may fit under one of the proposed RH TRU payloads contained in the draft RH TRU Acceptance Criteria. Because of the small diameter of the IXC, cribbing would have to be manufactured and installed in the IC to support the IXC so that it will not move around.
10-160B	The cask is certified for Type B remote handled TRU payloads but does not address the IXC waste form. The 10-160B can only handle up to 20 FGE. The worst case IXC contains about 12 FGE. The 10-160B can physically handle the six IXCs loaded at once in it. A remote handling system (similar to the "cake rack" system) would have to be developed. The payload would have to be added to the Certificate of Compliance (CoC). The payload may fit under one of the proposed RH TRU payloads contained in the draft RH TRU Acceptance Criteria.
Big Bertha	A CoC or an on-site safety analysis is not currently available for use. The cask has not been used in several years and would require extensive maintenance prior to use. It would not be certifiable for use off-site.
Super Tiger	It may be able to be used with an amendment to the CoC. The cask can

Table 3.1-1. Evaluation of Casks

Cask	Description/Issues for IXC Transport
	handle a Type B payload with up to 200 FGE. A special Type A box would have to be fabricated to hold the IXCs and would need to have shielding as the Super Tiger cannot handle RH payloads.

The condition of the resins residing in the IXC vessels also affects plans for treatment and disposal. Research by PNNL (PNNL 1999), Westinghouse Savannah River Company (WSRC 1997), and DuPont (DuPont 1978) indicates that the resins over the twelve years in storage have experienced crosslinking. Crosslinking of organics, such as resin beads, occurs in high radiation fields, including thermoplastic resins. The DuPont document showed that while polystyrene is radiation-resistant up to a dose of 10^8 R, at higher doses, there is significant hydrogen removal and carbon bond formation (i.e., crosslinking). Since the resin was in neutral solution with no oxidizers present and had a relatively high accumulated dose ($> 10^9$ R), the resin will have undergone extensive crosslinking. This will have caused the resin beads to agglomerate into large chunks, even potentially to the point of forming a single mass of material. With extensive crosslinking, the material will have reduced surface area and restricted access to the pores where the ions are exchanged, making difficult removal from the IXC vessel by any means.

The KBC project evaluated the following three methods for dispositioning the IXCs:

Ship the Waste to the SWD Facilities in an approved cask for long term storage. The KBC evaluated the possibility of packaging the IXCs into an existing Type B cask and transporting them to a SWD facility for long term storage. The KBC project could identify no currently approved cask that was licensed to handle the IXCs or could be licensed by NRC. Licensing by NRC is necessary to support the KE Basin closure schedule. The project then evaluated using a cask that is not DOT compliant for the payload and obtaining transportation safety documentation to allow the move on the Hanford site. The schedule and cost to approve a modified cask for onsite use take up to one year and up to $250,000, while cost to amend the license of a cask, would take about 1-2 years and $500,000 or more. The project schedule only provides about six months to obtain a qualified package which is not enough time for this option. This would only be an interim solution. Eventually, transport offsite or disposal onsite would have to be conducted, possibly requiring a transportation solution or design and fabrication of a burial container.

The project evaluated the hazards associated with handling the IXCs and possible dose consequences. Based on this evaluation, the KBC project determined that workers would be working in a dose rate field of 29 R/hr performing these activities. In addition, should an accident occur, the unmitigated dose consequence from a single IXC release is 1.4E-02 Rem to an off-site individual and 3.8E+02 Rem to the Hanford worker. Implementation of this management method is not in alignment with ALARA principles.

Request an off-site vendor to disposition the IXCs at an off-site facility.

The KBC project evaluated the possibility of tasking a qualified off-site vendor with removing the IXCs and properly dispositioning them off the Hanford site as is done in the commercial arena. The KBC project discussed this option with Mr. Chris Reno of Duratek, Inc., which performs this task for a substantial number of commercial facilities across the country. (Duratek is now *Energy Solutions*, due to a leveraged buyout Feb. 7, 2006.) Mr. Reno stated that his company may be able to perform this work; however the waste was not covered under the licenses for casks used to perform the transportation portion of this activity. Additionally, there were concerns associated with the integrity of the ion exchange beads given the length of time they have been in storage. Lastly, Mr. Reno stated that even if these hurdles could be overcome, the IXCs would require substantial decontamination to prevent contamination of the transportation cask. Currently, the IXCs and cells are classified as a high contamination area and exhibit 300,000 dpm beta/gamma per 100 cm^2 smearable. Therefore this option became no different from a perspective of risk and schedule support than the previous option, yet this option has the added risk of transportation in commerce. Implementation of this management method is not in alignment with ALARA principles.

Stabilizing the waste form using grout or concrete and transporting to the ERDF trench. The KBC project reviewed the option of placing a metal form around the waste storage location and filling all the annulus with flowable grout or cement. This alternative does not require workers to move the IXCs, thus reducing the possibility of release. In addition, all work can be done remotely, thus reducing the dose to the workers. Once grouted, the waste is in a form larger, but similar to the IXMs which have been determined to be appropriate for the management of these wastes (HNF-6495 2005).

The project supports the position that the most appropriate disposition path for the IXCs currently stored in the 105KE facility is to grout them in place and then add the resulting single monolith to an already established waste stream for monoliths for transport and subsequent disposal at the ERDF. Factors supporting this position are the huge reduction in dose consequences associated with removing the IXCs from their storage locations; lack of available transportation equipment; hazards associated with the waste; and the fact that monoliths are already planned as the result of removing the basin structure, and adding another monolith to this established waste stream would be environmentally protective, less worker exposure, less complex, less costly, and less time-consuming than developing a unique waste stream path for the IXCs.

3.2 Void Requirement Discussion

In order to prevent subsidence in the ERDF burial trench and possible future damage to the closure cap, ERDF has put in place several criteria within their waste acceptance criteria that will prevent subsidence. The following are excerpts from the ERDF Waste Acceptance Criteria:

4.4 PHYSICAL LIMITS

Packaged waste shall be structurally stable for disposal at the ERDF to limit potential subsidence. Packaged waste that is not structurally stable may be accepted at ERDF on a case-by-case basis and stabilized before disposal. Depending on the waste stream, stabilization may be accomplished by using soil, cement-based or other stabilization agents with acceptable structural characteristics, size reduction, a mixture of biodegradable waste and stabilizing agents, and/or voids filled with stabilization agents. Additional physical limits for waste forms including concrete, steel plate, piping and tube steel, building debris, structural steel, containerized waste, equipment, soft waste, and rebar are defined in the supplemental waste acceptance criteria (BHI 1997).

4.1.3 Control of Waste Form

The physical form of the waste shall be controlled to minimize void space in the ERDF and facilitate loading, transporting, unloading and handling of waste. Additional requirements regarding waste form are identified in the supplemental waste criteria (BHI 1997).

As stated in Section 4.4 of the ERDF Waste Acceptance Criteria, additional requirements can be found in the Supplemental Waste Acceptance Criteria. The supplemental waste acceptance criteria does not prohibit placing materials with void spaces, however the generator must demonstrate that the material will not lead to a subsidence issue, and the generator must develop a waste shipping and receiving plan (WSRP) to address any special handling requirements.

The voids in this package will exceed the steel debris criteria found in Section 1.4.3 of the supplemental waste acceptance criteria. However due to the extremely high dose rates associated with IXCs, it is unsafe to split, crush or otherwise handle the IXCs.

Although the voids are indeed greater than 2", the void is still minimal for the package, being estimated to be 0.5%. In addition to the void being relatively small, the void is contained within a pressure vessel able to withstand a pressure of 125 psi that is then surround by a substantial amount of grout. These two facts will prevent the package from subsiding in the future. This is also demonstrated by the fact that the ERDF has authorized the disposal of the Ion Exchange Modules (IXMs), which is a unit containing six IXCs encapsulated in concrete.

Based upon the robustness of the packaging proposed, strength of the IXC vessel itself, and fact that a similar waste form has been previously deemed acceptable at the ERDF; the KBC project believes that the package has been demonstrated to meet the void requirements contained within the ERDF WAC.

3.3 Macroencapsulation of the Lead Associated with the IXC Monolith

The IXC monolith will contain approximately 17,000 lbs of lead shielding. The lead exists as lead sheets that have been attached to a steel frame and skinned with metal sheets and painted to create the lead caves that store three of the six IXCs. The grouting plan calls for metal forms to be built surrounding the monolith. The activity of allowing grout to flow into all internal spaces and around the IXCs as well as the lead sheets will ensure the lead sheets are fully encapsulated by the grout, metal forms, and current concrete floor. The metal form will be attached to and designed to prevent cracking of the monolith during transport and disposal.

Based on this discussion it is obvious that this waste from meets the requirements of macroencapsulation found in 40 CFR 268.40.

4.0 DEFINITIONS

Stabilization (40 CFR 268.42) means "[a process that] involves the use of the following reagents (or waste reagents): (1) Portland cement; or (2) lime/pozzolans (e.g., fly ash and cement kiln dust)" (EPA-542-R-00-010).

5.0 REFERENCES

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